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OF

THE ENGINEERING SOCIETY

OF

THE LEHIGH UNIVERSITY.

ISSUED QUARTERLY.

FEBRUARY, 1887.

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PLATE LIII.—DAM ACROSS THE CONNECTICUT RIVER, AT HOLYOKE, MASSACHUSETTS.

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ABSTRACT OF PROCEEDINGS.

Thursday, December 2, 1886. — Meeting called to order by President LaDoo. The Treasurer reported a balance of $28.00 in the treasury, and delivered to the Society, "Trautwine's Engineers' Field Book," and "Trautwine's Railroad Curves," presented by the author, to whom a vote of thanks was extended. Messrs. H. S. Meily, S. H. Jencks, C. P. Conner and F. S. Bates were elected to membership. Mr. Bonnot read a paper on "The Necessity of Forest Preservation." Mr. Siebert, '86, gave some interesting accounts of his work on the United States Geological Survey in the far North-west.

Thursday, January 27, 1887.—Meeting was held at 4.00 P. M., and thirty members were present. Messrs. R. Daniels, H. M. Wetzel and M. L. Byers were elected members of the Society. The President read a letter from Mr. Siebert, '86. Papers were read, by Mr. Breckenridge, on the "Holyoke (Mass.) Water-Power," for which a vote of thanks was given, and by Mr. Phillips, on the "Economy of Maximum Gradients."

Thursday, Feb. 3.—Meeting was called at 4.00 P. M., with thirty-five members present. The Treasurer reported a balance of $59.94. Mr. Sattler was elected a member. It was moved by Mr. Hittell, and carried, that the Society present the University Library with last year's volume of the JOURNAL. The following papers were read: on "Power Brakes for Railways," by Mr. Parker; on

"Derivation of Formula for Force Necessary to Produce an Acceleration of Piston," by Mr. Glover; on "Externally Fired Boilers," by Mr. Hart; on "Method of Conducting a Topographical Survey in the far North-west," by Mr. Jones, written by Mr. Siebert, '86, and on "Proper Size of Relief Valves for Stationary Engines," by Mr. Bruegel, written by Mr. Hartshorne, '74. By motion, meetings will be held at 4.00 P. M. in future, until otherwise ordered. MASON D. PRATT, *Secretary*.

THE WATER-POWER AT HOLYOKE, MASS.

Read before the Society by L. P. Breckenridge, Instructor in Mechanical Engineering.

(Plate LIII, used to illustrate this article, was loaned by Am. Soc. C. E. The cuts of "Hercules" and "Boyden" turbines by the Holyoke Machine Co.)

In 1848 the first dam across the Connecticut River, opposite the present site of Holyoke, was completed. At about 10 A. M., November 16, the gates through which the water ran while the dam was being built, were closed; by 3.20 P. M. the water had risen to within 2 or 3 feet of the top, when all but about 75 feet at one end and 150 feet at the other rolled over and floated down stream on the crest of a wave 8 feet high. Something had been learned by experience. Another dam was built upon a different plan. This was completed in 1849, and since that time the waters of the Connecticut have been subservient to the use of man.

During the 36 years of its existence numerous repairs and additions have been made to this dam, but it was then and is now the largest over fall dam in the world. The length of the dam is 1017 feet. It is composed of heavy timbers, 12″x12″ being the smallest used. The upper surface of the plank of the dam is inclined at an angle of 21° 45′ to the surface of the water of the river.

Four million feet of timber were contained in the dam of 1849. The planking was trebled to a thickness of 18″ of solid timber (3 layers of 6″ each), trenailed, spiked and bound strongly together. The rolling top was then covered with sheets of boiler plate placed side by side and extending the whole length of the dam. The front of the dam presented the appearance shown in

Plate LIII. At two places water is running over the dam, but is prevented from so doing at other places by the flash-boards, held in position by rods of iron, placed at intervals along the crest of the dam. High water occurred about a month after this dam was completed, and six feet of water pouring over it produced a roar which is claimed to have been heard at Hartford, 34 miles down the river. Windows at Springfield, 8 miles below, rattled at the rate of 128 vibrations a minute. The next year there was in May 8½ feet on the dam; in 1854, 10½ feet, and in 1862, 12½ feet, which is the maximum to date. For 19 years the water poured over a dam similar that shown in Plate LIII. Ice in the Winter, logs in the Spring, water always. What wonder then that even the solid rock beneath was worn, and that in a line across the front of the dam a hole 20 to 25 feet deep was cut out, at places even undermining the dam itself and loosening some of the timbers along the heel. Something must be done. In 1868, '69 and '70, was built the apron down stream of the dam of 1849. Fig. 1 shows on one side a cross-section of the dam of 1848 (*A*), and the apron (*B*); as will be seen from the cut the apron is larger than the original dam. It is built of logs built up in perpendicular bins 6′ square and filled to the top with stone before covering. The estimated cost of this apron was $300,000. The dam in this condition did good service up to 1879; at this date and later breaks occurred, which showed themselves as whirlpools above the dam, indicating that water was flowing through or under it. These were repaired or filled up, but more breaks appeared, and from 1879 to 1885, these were a source of much loss of water as well as of possible danger to the entire dam.

The work on the dam during the Summer of 1885 can not in this brief article be described. For a detailed account of it, reference may be had to Vol. XV., *Trans. Am. Soc. C. E.*, where the work done is fully described by Mr. Clemens Herschel, the hydraulic engineer of the Water Power Co., under whose direction the work was planned and executed. Suffice it to say that the dam has been replanked its full length and many new timbers put in where decay had begun. The entire dam was filled with gravel and puddled, and this between May 29 and October 2, with water a large part of the time running over the dam, except where prevented from so doing by the coffers used where the work was being prosecuted. In the article cited above, under

the heading, "The Lesson of 1849 to 1886, in the Construction of Wooden Dams," Mr. Herschel says: "First and foremost, that a wooden dam should never be left hollow, nor should it be filled with stone. Let a row of sheet piling be put in, in some proper position, then puddle in gravel. Gravel is water tight, or soon becomes so; stone filling is not. Gravel will protect every timber it encases from rot for ever. Stone filling will permit decay and so will the moist, foul air to be found in the interior of all hollow dams. Worst of all is an entirely hollow dam.

Second.—In crib work two timbers should never be butted on top of another of the next course underneath. This would give each timber at the most a six-inch bearing, and should the lower timber become decayed at the edges, or the butting timber at the ends (both being places where decay is worst), the strength of the bearing is speedily reduced to zero. It looks well on a drawing or in new work thus to butt timbers and the covering plank, but a great deal may be learned in pulling an old dam to pieces, and were I to design a new dam I should do neither.

Third.—Don't make a masonry shelf on each abutment to take the place of the last bent or frame of the dam. When the dam settles or compresses under its load, as it must, the shelf does not follow, and the result is a distortion of the framing of several bents next to the abutments.

Fourth.—The back of the dam needs to be guarded against such abuse as the dropping of four-ton stones upon it, especially in the case of dams upon large rivers.

Fifth.—The shape of the dam should be so chosen with a view to preventing the excavation of large masses of the river bed and the formation of a pool below the dam. It is absolutely necessary to do this in the case of a gravel bottom; it should never be neglected in the case of a soft rock bottom; it should be done in many cases of a granite or other hard ledge bottom. A pool of water that can not be laid dry is a source of danger in all hydraulic works, for the reason that one can never be certain as to what may or may not be taking place below the water's surface, unless, indeed, periodical inspections be made in diver's armor, and even that would result in far less frequent examinations."

So much for the dam. The river surrounds Holyoke on three sides, being thus admirably suited for the site of a water-power. There are three systems of canals at different levels. The total

fall from the crest of the dam to the river at the lowest tail-race, one mile below, is 60 feet.

There are now in use about 15,000 horse-power by day and over 8,000 by night. There are 139 turbines in use, of which 59 run about ten hours a day, and 80 run from Sunday at midnight to Saturday at midnight, or 144 hours per week. The estimated capacity of the river is 30,000 horse-power. During a large part of the year the water is running over the dam, which it does with very little noise since the construction of the apron. Each canal has an overflow into the river separate from the water discharged by the wheels. The first level has an overflow into the second level and the second into the third. By this means the height of the water in the different levels can be carefully maintained. Mills requiring an even speed, as cotton or silk mills, are situated between the different canal levels so that their wheels run under a constant head of water. A large number of mills drawing water from the canals and discharging into the river are paper mills. Holyoke has been called the "Paper City" on account of the large amount of paper made there, averaging 200 tons a day. Philadelphia comes next with 69 tons a day.

At the western end of the dam is the gate-house (marked 1 on Fig. 1), a brick building upon the massive stone work which serves as one abutment of the dam. In this are placed 13 gateways. The gates are raised or lowered by power furnished by a water wheel at one end of the building. After the water has passed through the gateways it finds itself in the main canal from which all the other canals are supplied. The sides of this canal are of solid masonry; at the bottom its width is 140 feet; at the top 144 feet. About 22 feet of water is the usual depth in this canal. The overflow from this canal into the river is just below the gate-house. The canal then extends eastward about 1000 feet, where it divides, and the first level canal, of which this main canal is but the upper end, sweeps southward for about one mile gradually becoming narrower, at the rate of about 1 foot in every 1000. The other branch extends along in the same general direction for some 400 feet at which point is the overflow No. 2 into the second level.

All the water coming through the head-gates into the first level canal must find its escape in one of the following ways: (*a*) Principally through the wheels of the mills on this level into the second level; (*b*) some through wheels of mills near the head-gates

directly into the river; (*c*) through the gates or over the overflow No. 2 into the second level; (*d*) through the gates or over the overflow near the gate-house directly into the river. This last

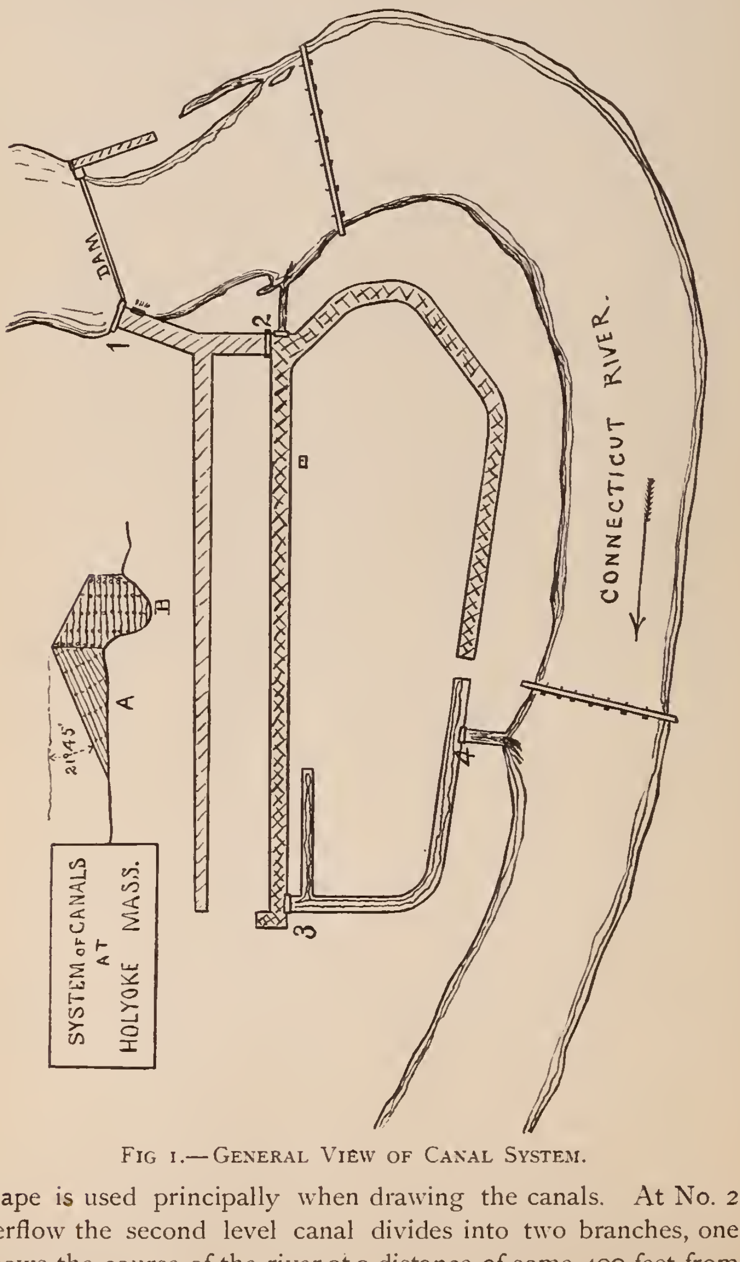


FIG 1.—GENERAL VIEW OF CANAL SYSTEM.

escape is used principally when drawing the canals. At No. 2 overflow the second level canal divides into two branches, one follows the course of the river at a distance of some 400 feet from

its bank, and thus is available for mills discharging directly into the river. The overflow from this level into the river is right at the foot of the overflow from the first level, so that one man at this station can either raise or lower the water in the second level. The other branch extends in a line parallel to the first level, also about 400 feet from it, receiving water from the mills above on the first level. At the southerly end of this branch of the second level water is drawn through the wheels of mills into the third level.

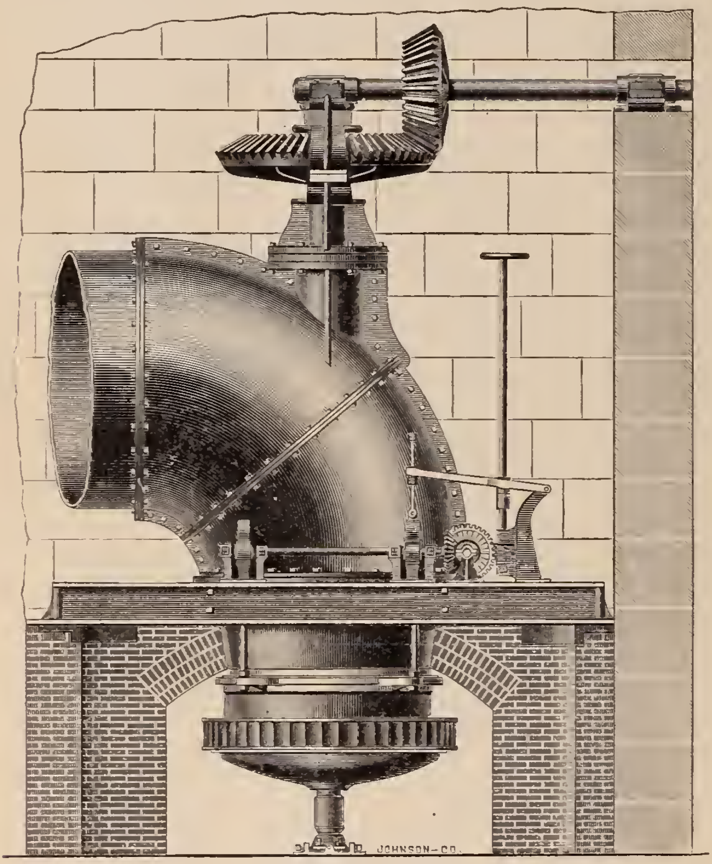
The overflow No. 3 from the second level into the third level is also at the extreme lower end of this branch. The third level from this point has one arm reaching up parallel to the second level to receive the waters from mills on it, and the other arm extending nearly to the river then follows its bank up the stream to a point where the second level will eventually end, thus encircling the city with a liquid band always ready to fall to a lower level and being compelled to do so through the ever-whirling turbine. No. 4 is the third level overflow into the river.

These canals during the Summer are drawn off at Saturday midnight and filled Sunday at midnight, so that all repairs to wheels, canals, wheel-pits, penstocks, tail-races, and so forth, must be made on Sunday. In Winter the canals are not drawn off and are usually frozen over.

The cost of power. One "mill-power" costs $300 per year. The number of mill-powers owned by different companies varies from 1 to 21.

The Holyoke mill-power is defined in the deeds of the company as follows: "Each mill-power at the respective falls is declared to be the right during 16 hours a day to draw from the nearest canal or water course of the grantors and through the land to be granted 38 cubic feet of water per second at the upper fall where the head and fall is 20 feet, or a quantity inversely proportionate at the other falls." This is equivalent to about 86.4 horse-power. A good turbine will derive 75 per cent. of this power from the water (under very favorable conditions 85 per cent.) making 65 horse-power, the commercial equivalent of one mill-power, or $4.62, the cost of one horse-power per year. The cost of one horse-power derived from the use of steam in an economical engine at Holyoke exceeds $20.00 per year, assuming large engines (160 horse-power), using three pounds of coal per horse-power per hour. Two dollars and three dollars per week

are common charges for one horse-power in cities. The Sears' estate at Boston gets $175.00 a year per horse-power. The Central Pacific Mills, at Lawrence, prefer to pay $60.00 a year per horse-power to running its engines of 1000 horse-power.



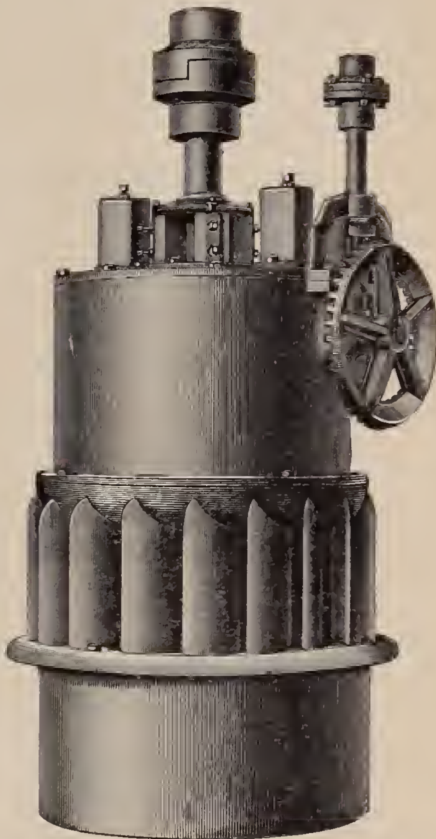
BOYDEN TURBINE.

The styles of turbines used at Holyoke are many, but the following list will show the principal ones: "Hercules," 62; "Boyden," 38; "American," 9; "Tyler," 7; "Risdon," 6; "Jonval," 3. As will be seen the Hercules and Boyden turbines furnish 75 per cent. of the power used there. These wheels are shown in figures *2* and *3*. The former is of the inward flow the latter of the outward flow type.

The efficiency of the Boyden wheels is high, at full gate reaching in some cases to 85 per cent., at part gate, however, the efficiency is much lower. The Hercules wheel gives its highest

efficiency at about 7/8-gate, and down to 1/2-gate its average efficiency is high. A wheel tested September 14, 1882, gave an efficiency of 0.835 per cent. at 0.64 velocity ratio, averaging 0.822 per cent. from 3/4 to full discharge and 0.81 per cent. from 1/2 to full discharge.

It is of much importance to have a wheel of high efficiency at part-gate. A wheel should be able to do its work at 7/8-gate, this so that its speed may be properly maintained by a governor—as well as its capacity—maintained in case of back water.



HERCULES TURBINE.

The Hercules was invented by Mr. McCormick and patented in 1876. It has reached its present state of perfection by the "cut and try" method. Over 200 of these wheels have been tested at the testing flume of the Water Power Co., and the success of the wheel is certainly attested by the large number now in use at Holyoke, where all the water used is measured and a charge made for any surplus drawn from the canals. The main features of the method of measuring the water used by the different wheels are as follows: For the purpose of making the necessary experiments on the wheels of their tenants, before they are set in the mills, the Water Power Co. has built at a large outlay a permanent testing flume. Wheels are tested here both for power and for amount of water discharged. They are usually tested at five or six different openings of speed gate, ranging from wide open to the opening at which the discharge is one-half that at full opening and at five or six different velocities

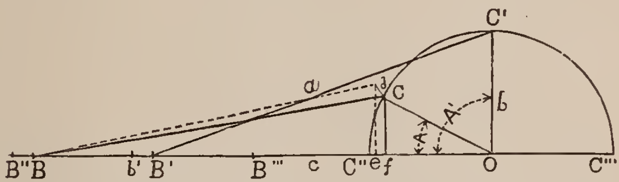
of revolution at each gate opening. The final result is that for all practical purposes the wheel has been converted into a water meter and its discharge will be known under any of the conditions under which it may be found at the mill. Besides this its efficiency or its value as a water motor is also known. After the wheels are tested they are set in the mills. They are then visited once every day and once every night (such wheels as are run nights), observations taken of the height of water above the wheel and height below—also the opening of the speed gate—from which data the amount of water flowing through the wheels can be calculated. The wheels in the mills are visited in different order and different days so that a general average of the conditions will doubtless represent what is taking place.

ON THE DETERMINATION OF PROPER SIZE FOR RELIEF VALVES FOR STATIONARY ENGINES.

In the Summer of 1883 an accident to a large Corliss Engine came under the writer's notice. The accident was undoubtedly caused by water in the cylinder, drawn over with the steam from overfull boilers. The most serious result was the splitting of the pillow-block, which, of course, had to be renewed before the engine was again serviceable. The mill depending upon this engine for its power was necessarily shut down while these repairs were being made—a very serious loss in production, besides the damage to the engine. It occurred to the writer, therefore, that some mechanical means might and ought to be adopted to prevent the possibility of the recurrence of such accidents. Knowing that relief valves were used upon locomotives for a similar purpose, the question arose as to the applicability of such a valve to a large stationary engine, and I accordingly wrote to a manufacturer of such valves, giving dimensions and speed of engine, and asking for information based upon their practice as to the requisite size of valve that would afford the necessary protection. Their reply was not very encouraging. The exact words I do not remember, but in substance it was that they could not inform me, and that they knew of no way to determine it except by trying the experiment on the engine in question, offering to

send several sizes of valves to try. Of course, I was obliged to decline the courtesy, one experiment being enough in that line. However, it did not appear to be a very difficult question to determine by calculation, and the following is the result of the writer's efforts in that direction. For convenience I have divided the steps of the process into separate problems:

Problem I. To determine the velocity of an engine piston at any point in its stroke in terms of the angular advance of the crank pin, which is assumed to have a uniform circular motion.



Let B'' and B''' represent the positions of the pin in cross-head at the beginning and end of a stroke and B and B' any other positions. C'' and C''' will be the respective positions of the crank pin at beginning and end of stroke, and C and C' any other positions corresponding to B and B' of the pin in cross-head. The angle A or A' will represent the angular advance of the crank pin. Let a represent the length of the connecting-rod and b the length of the crank, both of which are constant quantities for the same engine. Let c represent the variable distance between pin of cross-head and center of motion of crank pin. Now, while the piston is advancing this distance c is diminishing with exactly the same velocity as the speed of the piston at each instant, and it increases on the return stroke at the same rate also.

Now we have the equation, Cos $A = \frac{c^2 + b^2 - a^2}{2bc}$ or solving with reference to c. $c = b \cos A \pm \sqrt{a^2 - b^2 + b^2 \cos^2 A}$ in which cos A is $+$ or $-$ according as the crank pin is in the 1st or 2d quadrant (or on the return in the 4th or 3d). Since space divided by time represents velocity, we have in general $V' = \frac{A}{t}$ in which $V' =$ velocity of rotation of crank pin, $A =$ the angle of advance during any interval of time t, or $t = \frac{A}{V'}$ and the velocity of rotation being uniform, we have for an infinitesimal increment $dt = \frac{dA}{V'}$ Now during the time dt the distance c is dimin-

ished by the infinitesimal distance $-\ dc$ (negative, because decreasing), and we have for speed of piston at any instant of the advance $V = -\frac{dc}{dt}$ or for the return $-\ V = \frac{dc}{dt}$.

Now above we have $c = b \cos A \pm \sqrt{a^2 - b^2 + b^2 \cos^2 A}$

or differentiating $\quad dc = -\ b \sin A dA \mp \frac{b^2 \cos A \sin A dA}{\sqrt{a^2 - b^2 + b^2 \cos^2 A}}$

and since $dt = \frac{dA}{V'}$ we have

$$-\frac{dc}{dt} = \left\{ b \sin A \pm \frac{b^2 \cos A \sin A}{\sqrt{a^2 - b^2 + b^2 \cos^2 A}} \right\} V' = V,$$

again V' being assumed constant for the same engine is always $= \frac{2\pi R}{60}$ where R = revolutions per minute.

It will be noticed that the above equation gives $V = 0$ for $A = 0°$, or 180° and for $A = 90°$ we have $V = \frac{b 2\pi R}{60}$ which are evidently correct.

Problem II. To determine the velocity of piston at any given point in the stroke of a Corliss Engine as ⅛.

Note that it appears to be Mr. Corliss' custom to make $a = 6b$, so that if $b = 1$ $a = 6$, and in general for ⅛ stroke $c = a + b - \frac{1}{4} b = 6\frac{3}{4}$, and from 1st equation in Problem I,

$$\text{Cos } A = \frac{c^2 + b^2 - a^2}{2bc} = \frac{(6\frac{3}{4})^2 + 1 - (6)^2}{2(6\frac{3}{4})} = .78241 \text{ or } A =$$

38° 31′ and sin A = .62276, and taking a special case, where R = 61 revolutions b = 2 ft. a = 12 ft., and point of stroke as above at ⅛ we have from Problem I,

$$V = \left\{ 2(.62276) + \frac{4(.78241)(.62276}{\sqrt{144 - 4 + 4(.78241)^2}} \right\} \frac{2\pi 61}{60} = 9 \text{ ft. per}$$

second.

Problem III. Assuming for any given point of the stroke that the exhaust valve is closed and cylinder, in advance of piston, full of water, what must be the size of a relief valve that would prevent damage to the engine?

Assuming again that 200 ℔ per sq. inch is the maximum safe load on the cylinder, and that the efflux through the valve will meet with a resistance equal to that of any small and short tube, we have, according to Weisbach, $h = 1.505 \frac{v^2}{2g}$ in which h =

head of water, capable of producing the velocity v. Now 1 ℔ per sq. in. = 2.3 ft. head of water approximately, therefore 200 ℔ per sq. in. = 460 ft. for h and $460 = 1505 \frac{v^2}{2g}$ or as $2g = 64.4$

$V^2 = \frac{460 + 64.4}{1.505}$ or $V = 140$ ft. per second, as the attainable velocity of efflux through the valve under 200 ℔s. per sq. in. pressure.

In general, it is evident that

$$\text{Area of valve} = \frac{\text{area cylinder} \times V}{v} \text{ or}$$

$$\text{Diam. valve} = \frac{\sqrt{(\text{Diam. cylinder})^2 \times V,}}{v}$$ V being the speed of the piston at the instant it strikes the water, the exhaust valve being closed, and v the given velocity of efflux. In the particular case we have been considering, the diameter of cylinder = 20 inches, and V at ⅛ the stroke (from either end it is evidently the same) = 9 ft. per second.

Therefore,

$$\text{Diam. valve} = \frac{\sqrt{(20)^2 \times 9}}{140} = 5.\tfrac{7}{100} \text{ inches.}$$

It is probable, however, that few, if any, Corliss engines would have their exhaust ports closed so early in the stroke as ⅛ or ⅞ and on the other hand it would appear improbable that such a volume of water as the above would indicate, could be found in cylinders at closing of ports, except through flooding from condenser, which we are not designing to provide against. In the case of the engine to which I have referred as splitting the pillow block, the forward portion of the block was moved, about 1½ inches, as near as I can recall from memory, and it is probable, therefore, that the piston met the water at say $\frac{1}{30}$ of stroke from the end. Making the calculations on this basis, we have

$c = a + b - \frac{1}{15} b = 6\frac{14}{15}$ and

$$\text{Cos } A = \frac{c^2 + b^2 - a^2}{2bc} = \frac{(6\frac{14}{15})^2 + 1 - (6)^2}{2\,(6\frac{14}{15})} = .94263 \therefore \sin A$$

$= .33384$ and

$$V = \left(2\,(.33384) + \frac{4\,(.94263)\,(.33384)}{\sqrt{144 - 4 + 4\,(.94263)^2}}\right) \frac{2\pi 61}{60} = 4.\underline{936}$$

ft. per second, and therefore

$$\text{Diam. valve} = \frac{\sqrt{(20)^2 \times 4.\underline{936}}}{140} = 3\tfrac{76}{100} \text{ inches.}$$

If any valve is used, it would therefore seem necessary to be nearly 4 inches in diameter to afford adequate protection to a Corliss engine with cylinder 20x48, running 61 revolutions. It has been suggested to the writer that a weak spot left in the piston might be made to serve the purpose of a relief valve.

In engines of the Buckeye type, where the valve is held to its seat by steam pressure, and is made to leave its seat when the pressure becomes excessive on the inside, the necessity of any valve is not so obvious, and the weak spot in piston might be a sufficient additional safeguard. WM. D. HARTSHORNE.

METHOD OF CONDUCTING A TOPOGRAPHICAL SURVEY IN THE FAR WEST.

I shall try here to describe the manner of conducting a topographical survey in the mountainous regions of Oregon, as used by the United States Geological Survey.

Some point in the vicinity of the region where it is proposed to begin the work, accessible either by rail or stage, is chosen as headquarters, where the parties may outfit. Owing to the difficulties in obtaining and transporting supplies, the number of men is necessarily limited. Everything, men included, is carried on mule-back. The cook is an exception to this rule; he rides a mare, around the neck of which is hung a bell. The mules show a peculiar attachment to this animal, always keeping within sight of her. And here let me say that the much-abused mule is an invaluable animal in surveying mountainous or desert countries; his sure-footedness, as well as his hardiness, being indispensable qualities. Our mules were at one time, for four days and nights, with nothing better to eat than pine bark, and yet they seemed none the worse for it.

A topographical party, then, consists of the following: The topographer-in-charge, his assistant, a cook, and two packers; to these is sometimes added a man to read the barometer in camp, while the topographers are at work on a station. For a party as above, ten mules are required to carry provisions, instruments, bedding, etc., besides the five necessary for riding animals. Rations for from four to six weeks may thus be carried.

An odd sight it is to the novice to see a pack-train starting out from camp. In the lead, following the chief, rides the cook, on the bell mare, after which the mules string out in single file, the rear being brought up by the packers, encouraging the mules by select religious remarks and loving epithets.

Necessarily, the first thing to be done in the field operations is to cover the ground, which it is proposed to survey, with a triangulation. This work is not done with the accuracy used in the United States Coast Survey work, for the reason that the character of the work does not require it; nevertheless, considering the facts that the sights are generally taken upon sharp peaks, instead of signals or heliotrope lights, and that the instruments used read only to 10,″ and that finally, if the weather permits, the work on a point is finished in one day, the results obtained are admirable. Triangles whose sides measure from 75 to 150 miles in length, close within an average of 25″. The spherical excess in many triangles amounted to 30″.

Enough triangulation points having been determined and located on the plane table sheets, we are ready for topography. All topography is worked in by the plane table to a scale of two miles to the inch, the sheets being afterwards reduced for publication to four miles to the inch. The contours are sketched in, and here study and practice are required to be successful. The topographer must so impress the country he sees from one point upon his mind, as to be able to recognize the same features when seen from another point, perhaps twenty miles distant, and also to locate the point which he occupies, upon his plane table sheet. To aid him in this work, a sketch of the country, as seen from each point, is made by the assistant. If the topographer has the above mentioned qualities, his work is comparatively easy, in a country free from timber and smoke. The presence of the former doubles or trebles his labor, while the latter often stops him altogether for weeks and months at a time.

The carelessness of Indians in leaving their camp fires unextinguished, or the willful setting on fire of the underbrush by prospectors, so they may the better examine the ground, has destroyed much valuable timber, while the smoke from these fires is the surveyor's worst enemy.

Cañons, streams and roads whose courses cannot be determined accurately from stations, are meandered with compass and aneroid. The contours on both sides are sketched in, and distances are

obtained by noting the time it takes to travel them. The latter are checked by sights on prominent points wherever possible.

All levels on these surveys are obtained either by the barometer or by triangulation, or both, the barometer being the topographer's constant companion, not a little time being frequently spent in replacing broken tubes. Elevations are worked out with reference to some base station, in the vicinity of which the work is being carried on. The topographer usually works within a radius of about fifty miles of the base. The elevations of these stations above sea-level have been determined either by the United States Signal Service, by railroad surveys, or by the Survey itself.

On all points occupied by the topographer, whether as triangulation or plane table stations, and in all camps, hourly barometric readings are taken, being, of course, as nearly as possible simultaneous with those taken at the base. The aneroid is used, when moving from place to place, in determining elevations of divides, of streams crossed, and of such points as are not convenient to sight with the gradienter from stations.

The writer has now and again been asked, how it is that a topographer does not frequently lose his way, especially when camp has been moved while he is at work on a station. The answer to this is as follows: From all high points he impresses the topographical features of the country upon his mind, so that he can at all times, and in all places, recognize them, and consequently knows in which direction to travel, in order to reach a certain point. Sometimes, but rarely, he does lose his way, and it then becomes necessary for him to climb some high place from which to orient himself. If his mule has already been over the ground, he need but give him the rein, and he will bring him safely into camp, be the night ever so dark.

In conclusion, let me say a few words regarding the apparent conflict between the United States Coast and Geological Surveys. Although the character of their work is in many respects alike, yet their respective objects are entirely different. The former aims to give the country a survey precise in every respect, and to furnish maps which may be used for any purpose that maps can be used for, besides giving data for scientific purposes, such as determining the figure of the earth, while the latter will, as its name implies, furnish a geological survey of the United States; that is, a survey from which maps of sufficient accuracy for the geologist may be constructed. These maps have, however,

already proved themselves of value to railroad companies, and will further be of value as an excellent reconnaissance for more precise surveys.

It may be asked, why does not the geologist use the Coast Survey's maps? The answer is, he does wherever it is possible, but the refined methods used by that survey do not admit of making maps so rapidly as to supply the demand.

There are certain people who cry out loudly against one or the other of these works, some saying that the Coast Survey is too slow, and others that the Geological Survey is a waste of money. Those who judge merely by the quantity of work turned out, simply show themselves utterly devoid of judgment, while the others have never looked into the object of the two surveys.

Of the class who want no surveys whatever made, saying they can see no use in them, I will say nothing—they speak for themselves.

JOHN S. SIEBERT.

NECESSITY OF FOREST PRESERVATION.

"Man is a great disturber of things, and unfortunately, the changes which he brings about are not always for the better." The destruction of the forests is one of these changes not for the better; and it is time we were awakening to the danger which threatens us. For by the destruction of forests we invite all those evils which are to a great degree remedied indirectly by forests. Some of these evils are cyclones, which occur even now out West, doing immense damage; overflow of rivers, causing destruction of life and property, not to mention diseases and other calamities. Only last August, in the vicinity of Denver, the large irrigation ditches were shut down, and only enough water was allowed for domestic purposes. The cause of this short allowance can be traced to the wasteful destruction of forests on the slopes of the Rocky Mountains. These forests being a means of conserving the water-supply of Denver.

Forests are destroyed by fire, by man for commercial purposes and also to make way for agricultural purposes and by browsing animals.

The loss of timber by fire is insignificant compared to the damage upon subsequent forest growth. A fire destroys all

trees, old and young, giants ready for the ax, as well as germinating seedlings. The under-growth essential to protect the early growth of trees is consumed.

In 1882 over 30,000 circulars were sent out to get information in regard to the actual destruction of forest material by fire. Some returns were very vague, and the following table is liable to considerable error. This table is taken from the census of 1882–83, and the report was written by Prof. Charles S. Sargent, of Harvard.

In the United States, areas burned, in acres, 10,274,089; value of property, $25,462.250.

DIFFERENT CAUSES:

Improving pasturage	197
Clearing land.	1,152
Locomotives	508
Hunters	628
Camp-fires	72
Smokers	35
Malice	262
Prairie fires	12
Coal pits	9
Lightning	32
Indians	56
Prospectors	10
Travelers	2
Spontaneous combustion	2
Wood cutters	3
Carelessness	3

A vast amount of timber is used by the railroads of the country in construction and maintenance of their permanent ways. These inflict far greater injury upon forests than is represented by the consumption of material. Railway ties, except in California, are invariably cut from vigorous young trees from 10 to 12 inches in diameter, trees 20 to 30 years old, which if allowed to grow would at the end of 50 or 100 years afford immense quantities of valuable timber. Sixty million ties are consumed by the railroads of the United States every year. Supposing an average of two ties for each tree, that would make 30,000,000 healthy young trees destroyed every year.

The browsing of animals is one of the greatest hindrances to the permanency of forests, the injury due to that cause being only surpassed by that due to fires. It is common in all parts of the country to turn our domestic animals into the forests to pick up a scanty and precarious living, and this is the universal custom in southern and central portions of the Atlantic regions and in California. Sheep, cattle and horses devour immense quantities of seedling trees, the future forests of the country. They bark the older trees, and thus destroy their life. The sheep of California threaten to completely exterminate the noble forests of that State, and with them the entire agricultural resources of the State.

Where the prosperity of a country depends upon its forests, means are put into execution for the preservation of them. Maine, for instance, is dependent upon her forests for existence. Not many years ago the State was threatened with the entire destruction of her forests by fire and ill-regulated operations of lumbermen. These great forests, which were nearly destroyed, could not be restored, but methods for preserving the remnants were put into execution, and they still yield large and continuously.

Forests are very essential in mountainous regions. In northern Vermont and New Hampshire they guard the upper waters of the Connecticut and Merrimac; in New York the constant flow of the Hudson. Forests still cover the upper slopes of the Alleghany Mountains, and diminish the danger of destructive floods in the valleys of the Susquehanna and the Ohio. The upper water-sheds of the Missouri and the Columbia, the Platte and the Rio Grande, are still covered with forests, and preserve the California valleys from burial under the debris of the Sierras. To some extent these forests are almost in their original condition, their inaccessibility having saved them. But fire and ax are invading them everywhere and they will be in a few years something of the past.

I will quote from an editorial in the *Sanitary Engineer* of June last, under the heading of "Forests as Sanitary Agents":

"As population increases the need of food supply requires forests to give way for agricultural purposes, and a certain amount of destruction is therefore inevitable; but no one who is familiar with the process of stripping the hills and valleys of their natural growth of trees, which has been going on with an accelerating ratio in this country during the present century, can doubt that much of this has been unnecessary, that we have been

prodigally wasting our inheritance, and that it is high time that steps were taken, not only to prevent further unnecessary destruction, but also by systematic planting to repair some of the damage which has already been done. The presence of forests modifies the climate in their immediate vicinity, tending to prevent extremes of temperature, and often of moisture, and in this they may affect the character and severity of the diseases of a particular locality. They protect from violent winds, and to some extent, from malarial influences."

This editorial goes on to say how forests regulate the temperature of day and night, preventing those wide variations such as occur on deserts; storing the heat by day and radiating it slowly by night. The great value of forests lies in regulating and controlling the water supply of distant regions. This regulation is effected by the roots, plants that flourish in the shade and dead leaves which act like a sponge, retaining for a time the water falling upon them, and afterwards giving it off gradually to springs and streams, thus averting floods and droughts.

Systematic planting is the only remedy that can fill up the gap already made by useless destruction. In a few years this culture will be an industry, nd a profitable one if one has had sufficient training in that line.

The value of our forest products is not less than $800,000,000 a year. White pine is pretty nearly exhausted and other species will be as ruthlessly wasted when that is gone.

Mr. S. W. Powell in a very interesting letter to the *Century* of March, 1886, headed, "Timber Famine and a Forest School," says:

"When the resulting timber famine comes, it will for several reasons be a more serious calamity than would be the failure for ten consecutive years of any of our other crops.

First.—No other product has so great a money value.

Second.—Any other crop requires only a short time, usually a year, to reach maturity, while a forest needs from thirty to one hundred years.

Third.—We know how to raise other crops, but to superintend financially profitable timber-growing requires a long and severe special training, such as is afforded in the State forests of Continental Europe and in professional schools connected with them.

Fourth.—Failure, or even great scarcity, of working timber involves the derangement or total ruin of a vast number of important industries which wholly or in part depend upon the forest for their raw material. Some of these are metallurgy, building, wood-turning, tanning and the manufacture of articles made of leather, the making of wagons, carriages, furniture, musical instru-

ments, sewing machines, etc. In short, almost everthing one uses needs wood, directly or indirectly, for its production.

Fifth.—Destruction of the forest, especially upon steep hill-sides, causes irregularity in rainfall and other climatic changes very harmful to agriculture, commerce, manufacture and health, besides the loss from floods, of which during the past few years we have had such sad experience. It is estimated that last year's great flood in the Ohio cost $60,000,000, and if the harm done by the much higher water of 1884 was less, it was only because that of 1883 did not leave so much property within reach of inundation."

This gentleman goes on to say that we should never keep the hill-sides wooded merely as a preventive measure, but must learn how to make timber culture in such localities profitable, which can never be done without skilled labor and such professional training for the superintendents of this labor as the forest schools of Europe afford. I do not think it is out of place here to give some information in regard to these schools. In Germany there are nine such schools of high grade, and France, Austria, Switzerland, Italy, Spain, Portugal, Denmark, Russia and Sweden all have schools of the same sort. The course in these schools lasts from 2½ to 3 years, and is so severe that only those young men who have uncommon talent and industry can succeed. After this there is ten years or more of study and practice in a subordinate position, after which if he has done well he may get an appointment as district forester. Some of the best families are forest officials, and according to Mr. Powell there were a few years ago not less than 33 barons and knights employed in the crown forests of Prussia. As to the nature and scope of the studies pursued in these schools Mr. Powell gives:

" *First.*—Physical science, here comes in general and special chemistry, both inorganic and organic, physics, and meteorology with thorough work in geology and mineralogy. After this investigation of the "stoff" from which organisms are built comes botany in general, and that of forests in particular, with microscopy. Next is zoology, vertebrate and invertebrate, with special attention to the entomology, since insects are perhaps the worst enemies of trees. Withal the art of making "preparations" of animal organisms must be mastered.

Second.—Besides this work in natural sciences, which takes up about one-third of the school course, about one-half as much time is devoted to special mathematics, geodesy, interest and rent accounts, measuring wood, surveying, leveling and plan drawing.

Third.—After these physics and mathematics, which fill about half the course, come in such branches as public economy and

finance, the culture and implements, the protection, usufruct and technology of forests, appraising their value, making up statistics, construction of roads, etc.

Fourth.—Then follows jurisprudence, civil and criminal, as applied to forests. And in connection with the entire course there are excursions to the woods, so the knowledge gained shall not be too exclusively bookish." A. BONNOT.

ECONOMY IN FIXING A MAXIMUM GRADIENT FOR A RAILROAD LINE.

Much has been said and written in regard to the most economical location for a railroad line, *i.e.*, a location in which the sum of annual interest on the capital involved and the operating expenses have a minimum value. Most writers have connected the cost of operating an entire line of railroad with the maximum grade upon it. Engineers have located lines of railroads and parts of lines restricting themselves absolutely to an arbitrary maximum gradient, in accordance with this theory, in such a way as to create a perpetual burden upon the finances of the company.

It is not possible to decide primarily upon the best first cost of a proposed line of railway, for the traffic is in no case a determinate quantity, and hence the gross income can only be approximately estimated. Suppose the cost of a line of railway (20) twenty miles long is $1,000,000, and the experience of similar lines places the operating expense at one cent per ton-mile, the traffic at two cents per ton-mile and the yearly freightage at 250,000 tons. This line will then pay five per cent. return on the first cost annually. Now, whatever change be made in the location, and hence in the first cost, it must proportionately affect the net profit per ton-mile. It is clear that only a certain portion of the operating expense—one cent per ton-mile—can be eliminated by any change in gradient or other detail of location, while the first cost of the line may vary to any extent. Suppose this variation in operating expenses to extend from one-half cent per ton-mile, the expense on the imaginary air line and straight grade, to one and one-half cents on the least costly operable road. If either of these cases is to produce the same return from investment as the first, the cost of the lines will be respectively $1,500,000 and $500,000. It is highly probable that the

theoretical air line will cost a great many millions, while it is by no means impossible or indeed improbable that the operable line can be built for $500,000. It is therefore clear that the greater margin for adjustment will be found on the side of the less costly line. It is also clear that good policy forbids building expensive railroads for succeeding generations. If in the preceding case the road were built for $3,000,000 and the percentage of return by reason of increased traffic exceed the $1,000,000 line at the end of twenty-five years by fifty per cent., yet would the latter line be preferable. The former road could probably pay two per cent. return for the first ten years and fifteen per cent. per annum for the remaning fifteen years, while the latter might pay only the estimated five per cent. per annum.

People cannot live to-day upon the traffic to be carried next century nor are engineers expected to go upon the principle that they can. Hence a railroad must be built, if at all, in view of the traffic to be transported upon it within a few years of its completion.

Now let us imagine a proposed railroad route or a portion of it to consist of a series of undulations. The line is surveyed, the profile drawn and the engineer in charge is called upon to draw the grade-line in such a way that the road will, in short, pay the largest dividends. It is my purpose to show that a predetermined maximum gradient is a false basis, and that a location founded upon it will fail to conform in almost every case with the above premise of maximum dividends. Suppose a portion of a profile is represented by a line AB, and the engineer with his maximum gradient gm draws the line AC and CB. Now the volume of a given cut or fill varies almost as the cube of the depth since the section varies as d^2, and the length as d nearly. If A and B be taken to represent the terminals of the cut, its depth will then vary directly as the gradient or nearly so. Assuming that the operating expenses may vary as the maximum gradient, the engineer will by an arbitrary assumption draw a grade-line, which, if in error, affects the cost as its cube.

Again, let us suppose the engineer to vary his so-called maximum gradients and, according to the method of a prominent writer, construct a curve of annual expense and a curve of interest on first cost; and then attempt to find an ordinate in which the sum of these two is a minimum. As shown above, the cost may vary as the cube of the gradient; but it is possible that a slight varia-

tion may double the actual cost, as on a long incline the whole can be made cut by a very slight change in gradient. The curve of annual expense would be simplicity itself in comparison with this curve of interest on first cost. Indeed the more values of the gradient used ,the more clear would be their total want of connection. There is no wonder practical engineers are loth to attempt such a solution of the problem. It is indisputable that a maximum gradient affects the operating expenses of a road, but its value in respect to both cost of operation and amount of investment is entirely subsidiary to the local circumstances of each case. It is far preferable for the engineer to draw the preliminary profile with as few undulations as possible and avoiding deep cuts; and then search out in the field the shortest and most practicable route.

How frequently the first statement advanced in regard to a proposed railway is the value of the maximum gradient when length, curvature, probable cost and estimated traffic have a chief influence upon the operation and success of the road.

On this account the entire railroad system of Great Britian has been overpaid for. The London and Birmingham Railway, built with a maximum gradient of 1,330 or sixteen feet per mile, cost over $200,000 per mile. Had they not been sustained by the traffic of a wealthy and populous country all of these lines would have suffered bankruptcy.

The Union Pacific system, in our own Continent, is a monument of a similar idea. In one section of this road, between two points ten miles apart and with 840 feet difference of level, a route fourteen miles long and containing 1,300° of curvature was taken, and the straight line four miles shorter and with 600° of curvature less was rejected in order *to preserve a maximum gradient* of 60° per mile.

The continual lesson of railroad development shows clearly that it is not the ratio of operating expenses to earnings that makes one line a success and the second a failure, but it is the great burden of debt shouldered upon it by the errors of location.

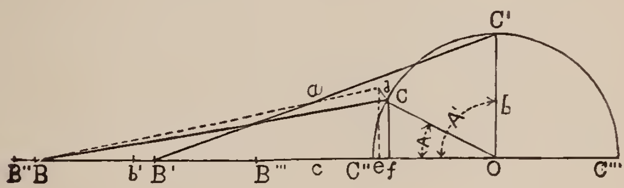
It is to be hoped withal, the increased efficiency of locomotives will bring the reign of King Gradient to a speedy close.

R. H. PHILLIPS.

TO DERIVE A FORMULA

FOR THE FORCE WHICH IS REQUIRED TO PRODUCE THE ACCELERATION OF THE PISTON-HEAD OF A STEAM ENGINE DUE TO THE USE OF A CONNECTING-ROD OF FINITE LENGTH.

In the Figure, let C' represent the crank pin of a steam engine, when 90° beyond the dead-center C'', and let $B'C'$ represent the connecting-rod. In this position the piston-head, instead of being at the middle of its stroke, where it would be if an



infinite connecting-rod were used, will be at point $b'B'$ beyond. This additional space $b'B'$, which the piston-head passes over while the crank is passing from C'' to C', is due to the velocity imparted by the vertical motion of the crank end of the connecting-rod; and this velocity is that whose law of acceleration we wish to find.

Let x = angle of advance of crank ($= C''OC'$).

Let W = angle at which main rod is inclined to be horizontal ($= C'B'O$).

Let S = space $b'B'$ corresponding to any value of x.

Let a = ratio of connecting-rod to radius of crank circle $\left\{= \frac{B'C'}{OC'}\right\}$

Now in Figure, if W takes an increment Cd, then S takes an increment ef. But we see from the figure that ef is the differential of the versedsine of W, therefore we have:

$$dS = d\,(\text{versedsine } W) = \sin W dW \qquad (1)$$

From this same figure we have:

$$\sin x = a \sin W \qquad (2)$$

Differentiating this:

$$\cos x dx = a \cos W dW, \text{ and } \qquad dW = \frac{\cos x dx}{a \cos W} \qquad (3)$$

From (2) we obtain:

$$\cos W = \frac{1}{a} \sqrt{a^2 - \sin^2 x}$$

Substituing this value of cos W in (3):

$$dW = \frac{\cos x dx}{\sqrt{a^2 - \sin^2 x}}$$

Substituting this value of dW in (1), we have:

$$dS = WdW = \frac{\sin W \cos x dx}{\sqrt{a^2 - \sin^2 x}} = \frac{\sin x \cos x dx}{a\sqrt{a^2 - \sin^2 x}} = \frac{\sin 2x dx}{2a\sqrt{a^2 - \sin^2 x}}$$

Now if the motion of the crank be uniform, each consecutive dx will be passed over in equal increments of time, therefore the ratio of dS to dx will be the same as the ratio of V to the velocity of the crank. Consequently, making the velocity of the crank equal to unity, we have:

$$V = \frac{\sin 2x}{2a\sqrt{a^2 - \sin^2 x}}$$

Since acceleration varies as the differential coefficient of the velocity, we have only to differentiate this equation to find the law of change of the acceleration. If this be done and the equation reduced to its simplest form we find that:

$$f\,(=\text{acceleration}) \propto \frac{dV}{dx} = \frac{a^2 + \sin^2 x\,(\sin^2 x - 2a^2)}{a\,(a^2 - \sin^2 x)\,\frac{3}{2}}$$

$$\text{Therefore, } f = c\frac{a^2 + \sin^2 x\,(\sin^2 x - 2a^2)}{a\,(a^2 - \sin^2 x)\,\frac{3}{2}} \qquad (4)$$

To determine the force required to produce this acceleration, we know that a force varies as the acceleration which it produces; therefore:

$$F\ (=\text{accelerating force}) = C\,\frac{a^2 + \sin^2 x\,(\sin^2 x - 2a^2)}{a\,(a^2\ \sin^2 x)\,\frac{3}{2}} \quad (5).$$

To determine the value of the constant C, we have to find, by some means, the exact value of F for some particular value x, and then equate the value of F thus found with the value of F determined from (5). Take $x = 0$ as this particular value of x, or, in other words, suppose the crank to be at the dead-center C''. Then $\sin x = 0$, and (5) reduces to

$$F = \frac{C}{a^2} \qquad (6)$$

But in this particular position the end C' of the connecting-rod will be revolving about the end B' with a velocity equal to the velocity of the crank, and the pull exerted by the piston-

head will be the same as that which would be exerted by its centrifugal force if it were concentrated about the end C' of the connecting-rod. The centrifugal force under the conditions named would be $\frac{mv^2}{ar}$, ar being the radius in this case, v the velocity of the crank, and m the mass of the piston-head. Equating this value with that of (6) we have:

$$F = \frac{C}{a^2} = \frac{mv^2}{ar} \text{ from which we get } C = \frac{amv^2}{r}$$

Substituting this value of C in (5) we get

$$F = \left\{\frac{mv^2}{r}\right\} \left\{\frac{a^2 + \sin^2 x\,(\sin^2 x - 2\,a^2)}{(a^2 - \sin^2 x)\,\frac{3}{2}}\right\}$$

which is the equation sought. If $\sin x$ be taken as the independent variable and the two principal diameters of the crank circle be taken as axes, the construction of the locus of this equation will be much simplified.

J. B. Glover, Jr.

EXTERNALLY FIRED BOILERS.

The simplest form of these boilers is a plain cylinder set in brick-work. This type of boiler is largely used in sections of the country where coal is cheap or in the lumber regions, where saw-dust and slabs are used as fuel. In many cases where fuel is abundant and cheap, and the feed-water "hard" and apt to form a troublesome scale, cylinder boilers recommend themselves as being at once easily managed, easily cleaned, offering, with the exception of the sphere, the strongest possible form to resist bursting, and affording the readiest facility for examination and repairs, and for a given weight or efficiency of heating surface, the lowest priced boiler now in the market.

These boilers steam well and prime less than any other form. In mining and lumber regions they are especial favorites, and it would be difficult to displace them, especially if the feed-water is impure. They are also used extensively at blast furnaces and to a large extent in rolling mills. An argument used against externally fired boilers is that the plates immediately over the furnace are liable to become over-heated, either by too hard "firing" or by the accumulation of scale in the boiler; the pres-

sure being internal, the tendency to rupture being that of bursting. The plates, which are none too strong, to begin with, and being further weakened by overheating, become dangerous in the extreme; consequently the boilers are liable to explode at any time when overworked.

There is much appearance of truth in the argument, but fortunately it has not been verified in actual experiments. However, I do not deny that explosions have occurred by the overheating of the plates, due to the accumulation of scale, which prevented the contact of the water with the plates. Explosions due to this cause are what have jeopardized the value of these boilers, not that the defect is in their construction, but you may find it in the management, that the proper precautions are not taken to remove the scale before it becomes too thick. If the question be resolved to that of absolute and not relative safety, and you should ask whether any form of riveted boiler, either externally or internally fired, could be made *absolutely* safe, I would answer, no. It then becomes a matter of relative safety. This can be secured only by a careful selection of plates of the best proportions and workmanship. Cylinder boilers usually range from 30 to 50 inches in diameter, and from 5 to 12 diameters in length.

Boilers of great length, as for instance, the blast furnace boilers at the Bethlehem Iron Company's Works, which are 70 feet long, have the advantage over those fitted with flues or tubes, the length of which rarely exceeds 20 feet, by presenting a greater surface for the absorption of the heat from the gases. These long boilers are great favorites at the blast furnaces where carbonic oxide gas is used principally as fuel. The shorter boilers are usually set in "batteries" of from two to six. The first number is a good arrangement where we have a large number of boilers, so as to permit cleaning or repairs to be made without interfering with the others in use. The method of setting these boilers depends to a great extent upon their length. If they are from four to six diameters in length, we allow their ends to rest upon brick walls; and when of greater length, as those used at blast furnaces or mines, we suspend them. I think two points of suspension are to be recommended on account of the distortion of the boiler, due to the unequal heating of the different portions of the shell. It has been said against cylinder boilers that they are not economical in the use of fuel. This may be a fact, but if more

attention were paid to the setting of the boilers, this difficulty would vanish. It very often occurs that the furnaces are too large, as is also the space under the boiler and the openings leading to the chimney; and that the draft is regulated at the ash-pit door. This is far from the best way of getting the greatest evaporation in a cylinder boiler. There should be walls so constructed as to cause the hot gases to strike against the boiler as much as possible. Then there should be a damper arranged to be manipulated at a convenient place, to regulate the flow of gases from the furnaces. This damper should be so adjusted as to allow as much gas to escape from the furnaces as there is oxygen necessary to supply the burning fuel. This method will be found to give far better results than by allowing the damper to remain wide open and regulating the supply of air through the ash-pit doors.

The transition from a cylinder to a flue boiler is an easy and a natural one, and probably suggested itself as a means of utilizing the waste gases passing into the chimney. The two-flue boilers are well known and afford good facilities for cleaning and inspection; they steam well and permit good circulation of water. By increasing the number of flues and decreasing their diameters we get the well-known tubular boiler. This is a splendid type of boiler where the water is pure and clean. Designers of these boilers differ in opinion as regards the proper diameter of the tubes; some advocate diameter rather than length, while others advocate the reverse. Some have an idea that by increasing the number of flues we would increase the power of the boiler. This is wrong. There is a limit to the number of flues, as too many may so prevent the circulation of the water as to diminish the evaporation instead of increasing it. This will cause priming, and may lead to overheating of the plates. At the Bethlehem Iron Company's works there are six boilers in one "battery" on the north side of the Lehigh Valley Railroad, three tubular and three cylinder. The cylinder boilers are forty inches (40″) in diameter, and fourteen feet nine inches (14′ 9″) long. They are laid parallel and directly over the fire-grate. The tubular boilers are fifty (50″) inches in diameter and fourteen feet five inches (14′ 5″) long. They are laid parallel to each other and perpendicular to the axis of the cylinder boilers. The thickness of the plates of the cylinder boilers is three-eighth of an inch ($\frac{3}{8}''$); that of the tubular boilers being seven-sixteenth of an inch ($\frac{7}{16}''$). The grate area is ninety-one square feet.

The number of flues in each tubular boiler is forty-seven (47), and each flue has an outside diameter of three inches (3″).

The total amount of heating surface of the cylinder boilers is 204 square feet. The flues of the tubular boilers expose 1,458 square feet, the ends of the tubular boilers, 40.8 square feet, and the shell of the boilers exposes 255 square feet, making in all a total of 1,959.8 square feet. Now to find the amount of water evaporated per hour per square foot of grate area, we use the empirical formula for stationary boilers;

$$W = 0.0222\, r^2 + 9.56\, C$$

$$W = .0222 \times (21.51)^2 + 9.56 \times 15$$

$W =$ water in pounds evaporated per hour per square foot of grate.

$$r = \frac{1959.8}{91} = 21.51$$

$r =$ ratio of square feet of heating surface per square foot of grate $= \frac{H.\ S.}{G.}$

We suppose $C = 15$ pounds. $W = 153.67$ pounds.

$C =$ pounds of fuel consumed per hour per square foot of grate.

$$\text{Boiler Power} = \frac{W \times G}{30}$$

$G =$ area of grate.

$$HP = \frac{153.67 \times 91}{30} \qquad HP = 466.17.$$

It takes about 30 pounds of steam to equal one horse-power. Or one boiler has a horse-power of 77.68. The boilers "blow off" at 55 pounds, causing a stress of 2,933⅓ pounds, longitudinally, on the fibers, giving us a factor of safety of 18.4. This is for the cylinder boilers, assuming the tensile strength of the plates as 54,000 pounds.

G. A. Hart.

WE are pleased to note that one of our articles in last issue, on "Early Surveying Instruments," by Mr. J. S. Siebert, C.E., was republished by the *Engineering News*. It is our aim and desire to publish matter, not only of interest to the members of the Engineering Society, but that will be of value to practical engineers and to the Alumni. We are enabled to do this more and more with the increase of interest of the Alumni in our Society, and shall try to publish in each number articles from our professors and instructors, and any contributions that we may receive from the Alumni.

The Engineering Society was never in a more prosperous condition, and the interest taken is certainly very encouraging to those who have the success of the Society at heart.

ON the 11th and 12th of February the Senior Mechanical and Mining Engineers were taken by Mr. L. P. Breckenridge to New York, and Stamford, Conn. Various works were visited, among which were the Yale and Towne Works at Stamford and the Worthington Pump Works at Brooklyn. We hope in our next number to publish a paper giving a description of the various works visited and the machines that were noted particularly.

We hope to be able to publish also at an early date an account of the experiments made by Mr. Breckenridge, assisted by the Senior Mechanical Engineers, for testing the efficiency of the Dickson Compound Pumping Engine, now in use at the new South Bethlehem Water Works.

ALUMNI NOTES.

1871.

—F. L. Clerc, C.E., is now located at Joplin, Mo.

1874.

—W. D. Hartshorne, C.E., Superintendent of the Arlington Mills, Lawrence, Mass., has sent a paper to the Engineering Society, which we publish with this issue, giving the result of some calculations on a safety valve for steam cylinders.

1875.

—Prof. E. H. Williams, Jr., E.M., has revised Vol. 13, Van Nostrand's Science Series, "Gases Met With in Coal Mines," by J. J. Atkinson. The principal addition is a discussion of the effect of coal dust as an explosive material. The book is published in the same series as the original.

1880.

—G. E. Potter, C.E., is now at Ashland, Ohio.

1884.

—W. B. Foote, E.M., has just come North from Alabama to study in detail blast furnace practice; he will take the Superintendency of a plant there when he returns.

—J. F. Merkle, C.E., has gone to Pittsburgh, where he is working for a large pipe-line company.

1885.

—F. Freyhold, C.E., has gone to St. Paul, Minn., where he expects to engage in engineering practice.

1886.

—G. H. Cobb, M.E., is Assistant Mechanical Engineer for Grey's Ferry Chemical Works, Philadelphia, Pa.

—C. A. Junken, C.E., writes himself Civil Engineer and Surveyor, 147 Dakota Avenue, St. Paul, Minn.

—C. H. Veeder, M.E., has left the Weed Sewing Machine Company and is at present draughting for the Calumet & Hecla Mining Company, Calumet, Mich.

—J. S. Siebert, C.E., is with the Pennsylvania Company, which operates all lines of the Pennsylvania Railroad west of Pittsburgh; his address is 116 Sandusky Street, Allegheny, Pa.

—J. W. Richards, A.C., has lately published in book form his thesis on "Aluminium." Until this volume was published, there was no complete work on this subject in the English language; the material was taken principally from English and American papers and magazines, and translated from the French and German. The book is spoken of very highly by the critics, and the *Engineering and Mining Journal* says of it: "A guide to our knowledge of the properties and mode of production of this metal was much needed in technical literature, and this want Mr. Joseph W. Richards has endeavored to supply by his lately published volume, now before us, in which a great number of facts relating to the history and mode of production of aluminium, its properties, and those of its alloys, have been brought together, making a very useful compendium."